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THE SPECTRAL ALBEDO OF THE SNOW AND VEGETATIVE COVER

by K. Ya. Kondrat'yev
Z. F. Mironova
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The investigation of the spectral albedo of natural underlying surfaces is a matter of great interest for the solution of a variety of problems in the fields of meteorology, bioclimatology, lighting physiology, aerial photography and other branches of science. But the information currently available on the spectral albedo is fragmentary and none too reliable. All the data on the spectral albedo of natural underlying surfaces have been acquired by making measurements with glass light filters, characterized by a high level of radiation filtration, or by measuring the spectral brightness of various natural formations in fixed directions with the use of monochrometers and photographic or photoelectric spectrum recording [1]. In the first case the measurements make it possible to determine the albedo in the usual sense (the ratio of hemispheric streams of reflected and incident radiation). But the relationship between the albedo and wavelength cannot be adequately characterized by the use of large and frequently overlapping regions of the spectrum. In the latter case, monochromatization is quite satisfactory but what it measures is the brightness which is identical with the albedo only when the reflecting surfaces are orthotropical. But the actual underlying surfaces are always non-orthotropical [2].

In 1953-54 the department of atmospheric physics of the Leningrad University designed a spectrophotometer with a photoelectric recording device that made it possible for the first time to make fairly reliable

[redacted]

measurements of spectral albedo of natural underlying surfaces. The basic components of this device, described in (3), are: a photometric sphere whose internal surface is covered with a magnesium oxide (radiation receiver), a monochrometer with optical glass, and an FEU-19 photoelectric multiplier with a direct current amplifier. The use of a monochrometer with optical glass made it possible to measure the spectral albedo within a wavelength range of 0.40-0.85 micron. The width of the measured spectral sections in the mentioned wavelength area fluctuated from 5 to 35 millimicron.

The preliminary results of the albedo measurements on certain surfaces made in 1955 are cited in work [3]. Investigations have continued since that time and been expanded in connection with the International Geophysical Year.

The purpose of this article is to analyze the measurements of the spectral albedo of various natural underlying surfaces made in the past two years at the Karadag Actinometric Observatory (Crimea) near the Koltushi settlement (Leningrad oblast) and at the scientific training station of the Leningrad University in the village of Sablino (Leningrad oblast). Major attention has been focused on the study of the albedo of the snow cover which varies a great deal with the state of the snow cover and lighting conditions.

1. The Snow Cover

The numerous measurements of the integral albedo of the snow cover [1, 4] are indicative of a high degree of variability of the snow albedo. The albedo changes from values close to 1 to about 0.30 (impure wet snow at the end of the snow-melting season) depending on the condition of the snow cover (structure, impurity, wetness, compactness). The integral snow albedo is to a lesser extent affected by lighting conditions (the height of the sun, the angular intensity distribution of scattered radiation, the changing spectrum composition of incident radiation). The daytime changes of the integral albedo of the snow cover, produced by changing lighting conditions, are therefore not very prominent.

In some cases of a stable snow cover with invariable properties, the daytime changes of the integral albedo cannot be discerned at all [4].

Not counting the small number of pyranometric measurements with the use of glass light filters and the few measurements of the spectral coefficients of the snow brightness [1, 4], the spectral albedo of snow has practically not been investigated. This accounts for the priority given in this work of the characteristics of the radiation reflection by the snow cover in various regions of the spectrum.

The observations discussed further on were made near to Koltushi (March, 1957) and the station of Sablino (February-April 1958).

In view of the multiplicity of factors determining the changing albedo of the snow cover, we shall first discuss the group of factors characterizing the effect of the snow condition on the spectral albedo. We will then study the effect of the light conditions and, in conclusion, analyze the daytime characteristics of the spectral albedo of the snow cover. We should point out, however, a strict differentiation of the effect of individual factors will be impossible as the actual observation conditions always involve a complex picture of "interwoven" factors.

Figure 1 shows the average results of 11 series of observations of dry pure snow in the course of three cloudless days. The observations were occasionally marred by the appearance of cirrus clouds, snowdrift or haze. But despite the similar observation conditions during those three days, the albedo revealed considerable differences on different days. A common characteristic was a maximum albedo in the shortwave region and an increasing albedo in the region near the infrared spectrum. The reflection selectivity was not very pronounced. The increasing albedo we found in the shortwave region fully agrees with the measurements of the spectral brightness coefficients of freshly fallen snow taken by E. L. Krinov [5], but contradicts the results achieved by N. N. Kalitin [6] indicating a monotonic diminution of the albedo in the direction from the visible to the ultraviolet region of the spectrum. The latter circumstance is explained by the fact that the maximum albedo occurs near the 410-450 millimicron wavelength, while the effective wavelength of the light filters used by N. N. Kalitin for the shortwave spectral region amounts to 380 and 450 millimicron. The maximum reflection in this case was therefore by-passed in view of the inadequate resolving capacity of the entire set of light filters. It was the first time we observed the increasing albedo in the near infrared region of the spectrum. E. L. Krinov's data [5] reveal only an insignificant increase in the albedo in the direction of long waves in some cases, and N. N. Kalitin [6] made use of light filters designed for effective wavelengths of 600 and 900 millimicrons in the near infrared region of the spectrum. According to [6], an albedo λ = 900 millimicron is less than one for λ = 660 millimicron. This prompted N. N. Kalitin to conclude that the albedo is monotonically diminished with the increasing wavelengths in the near infrared region of the spectrum. The monochrometer at our disposal enabled us to measure the wavelength up to about 800 millimicron. We therefore do not have the information for $\lambda >$ 800 millimicron. But an examination of the results cited in Fig. 1 clearly indicates an increasing albedo in the region of $\lambda >$ 650 millimicron. If the results achieved in [6] are valid, a maximum reflection should occur near the 800 millicron wavelength. As was already pointed out, the curves shown in Fig. 2 represent the averages of a number of similar curves obtained for a given day. An analysis of the "unit" curves would reveal that the spectral albedo of the snow cover goes through considerable changes in the course of a day. This can be seen in Fig. 2, for example. A close look at that figure reveals that the relationship between the albedo and the wavelength goes through such substantial changes in the course of the day that it even loses its basic qualitative characteristics. The maximum albedo in the ultraviolet and the near infrared regions of the spectrum observable in the forenoon and at noon shift toward the center of the spectral section under investigation (500-600 millimicron). And here the relationship between the albedo and the wavelength becomes similar to the one observed by N. N. Kalitin (6). It should be pointed out that these data were obtained under changing lighting conditions (from a clear to an overcast sky -- see Appendix 1).

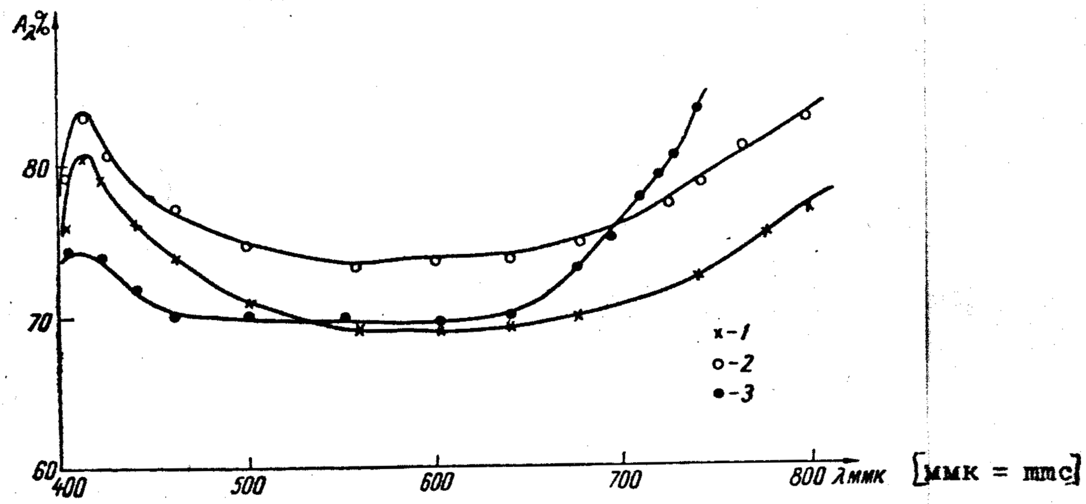


Fig. 1. The relationship between the snow albedo and wavelength under a cloudless sky (average results).

1 - March 4, 1957. Dry, compact, pure and large-grained snow;
2 - March 7, 1957. Dry, loose and fresh snow;
3 - March 23, 1957. Fresh, dry, loose and hilly snow.

It is possible that this substantial variability of the spectral albedo accounts in large measure for the discrepancy between our average data and N. N. Kalitin's results. The fact that N. N. Kalitin's observations were made primarily under a continuous overcast apparently also plays an important part.

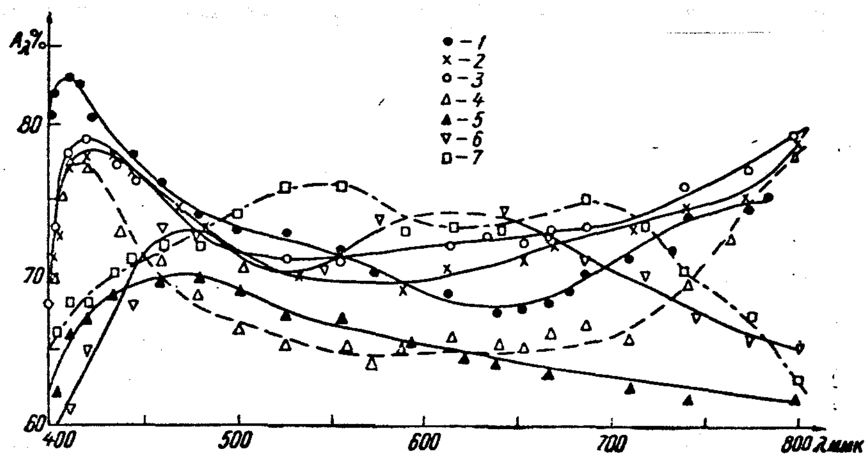


Fig. 2. The relationship between the snow albedo and the wavelength under a cloudless sky.
March 4, 1957. Koltushi. Compact, pure and long-grained snow.
1 - 11:00 am; 2 - 12:00 noon; 3 - 1:00 pm; 4 - 2:00 pm; 5 - 3:00 pm; 6 - 4:00 pm; 7 - 5:00 pm.

The variability of the spectral distribution of the albedo in the case of fresh snow is particularly important for the short waves ($\lambda <$ 450 millimicron). Curve 3, Fig. 1, for example, was obtained by averaging up six separate curves in the period between 10:45-17 o'clock corresponding to the albedo values for wavelengths of about 400 millimicrons which change nonmonotonously with time from 50 to 80%. It should be pointed out that the haze in the second half of the day on 23 March 1957 produced a particularly sharp change in the albedo. Curve 3 representing fresh snow in Fig. 1, is therefore so abnormally low in the shortwave region. Intense variability of the spectral albedo is typical also of melting and impure snow.

As for the causes of the considerable changes of the spectral distribution of the albedo in the course of the day, they are undoubtedly due primarily to the changeable condition of the snow cover and the spectral albedo. Considerable attention is now being focused on the development of methods for calculating the integral albedo of the snow cover on the basis of the different characteristics of the latter. This is a useful and desirable field of investigation. It is possible, however, that the solution of the inverse problem, that is, the determination of the properties of the snow cover by the spectrum of radiation reflection, is just as promising. At any rate, the successful investigations of the properties of matter and on the basis of reflection spectra carried out in recent years in the field of physical objects and spectroscopy justify an optimistic attitude toward the possible solution of the mentioned inverse problem.

If a more or less marked increase in the albedo in the direction of short and long waves is on the average characteristic of dry and pure snow, the opposite is, as a rule, true of impure or wet snow. This may be seen, for example, from Fig. 3 where the figures apply to dry, impure and porous snow.

Naturally, the spectral albedo of all wavelengths diminished with the increasing contamination and wetness of the snow. This point is illustrated by the respective figures cited in Table 1.

Table 1

The relationship between the spectral albedo of the snow and the condition of the snow cover

Date	Time (hrs)	Cloudiness	Condition of snow cover	Wavelength (millimicron) 400	501	615	742	800
				Albedo (%)				
3/6/57	14	10/0	Dry, pure and loose snow	72	83	84	98	98
3/11/57	14	10/0	Wet and dirty snow	55	59	58	70	67

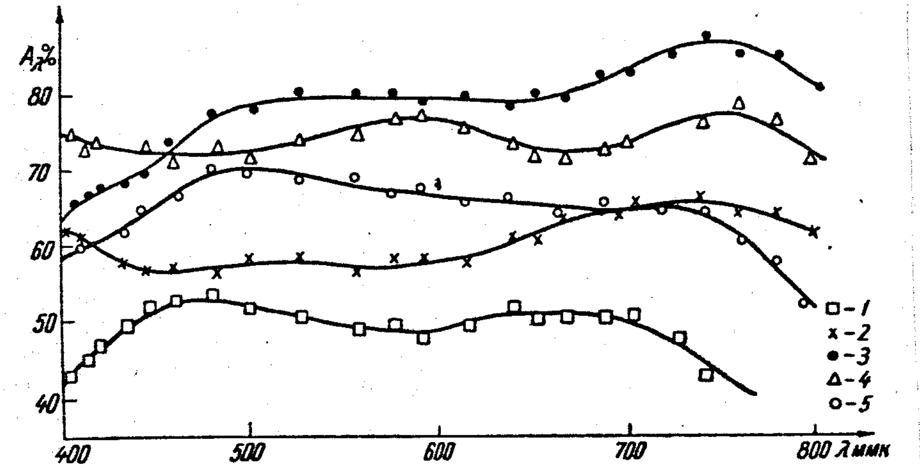


Fig. 3. The relationship between the snow albedo and the wavelength under a cloudless sky.

March 31, 1958. Wet and impure snow. 1 - 12:00 noon; 2 - 12:00 noon; 3 - 1:00 pm; 4 - 5:00 pm; 5 - 6:00 pm.

Apparently, the maximum albedo in this case is preserved but the albedo magnitudes are substantially reduced.

The roughness of the snow cover also has a considerable effect on the magnitude of the albedo. An example of the roughness effect on the albedo is cited in Table 2. As the figures in that table as well as other observation results indicate, the snow albedo diminishes in all the wavelengths under consideration with increasing snow roughness (other conditions being equal).

Table 2

The relationship between the spectral albedo and the roughness of the snow cover

Date	Time (hrs)	Cloudi-ness	Condition of snow cover	Wavelength (millimicron) 400	501	615	742
				Albedo (%)			
3/7/57	10	0/0	Dry, pure and loose snow and flat surface	73	76	73	70
3/17/57	10	0/0 haze	Dry, pure and loose snow and uneven surface	65	61	60	60

This result is quite natural from the point of view of the general concepts of the effect of roughness on the albedo.

As was pointed out earlier, the chief variability factor of the spectral albedo of snow is the condition of the snow cover (the snow structure, wetness, impurity and roughness). There is no doubt, however, that lighting conditions also play an important part. Obviously, the change of the spectral albedo of the snow will depend on the nature of the angular distribution of the incident radiation in view of the non-isotropic aspect of the radiation reflection by the snow.

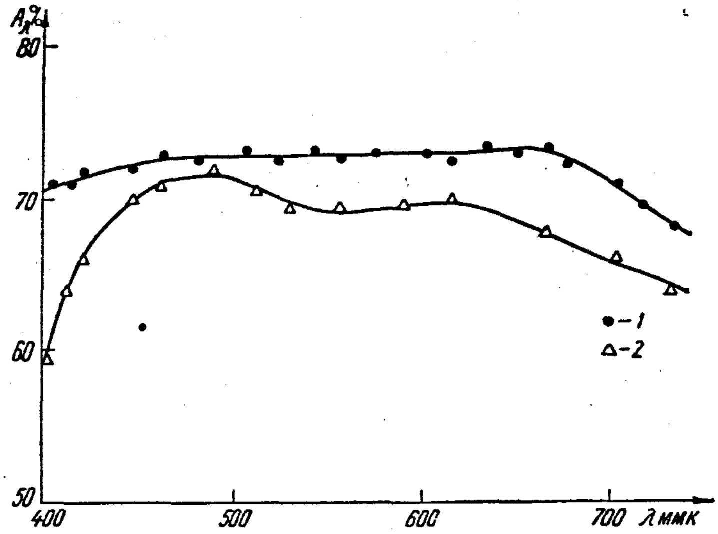


Fig. 4. The relationship between the snow albedo and the wavelength under a high overcast or a clear sky and turbid atmosphere.

1 - March 18, 1957. Fresh, fine-grained and pure snow.
2 - March 4, 1957. Compact, pure and large-grained snow.

Since the nature of the angular distribution of total radiation is first of all determined by overcast conditions, there must be a relationship between the spectral albedo of the snow and the overcast. Unfortunately, it is very difficult to "isolate" the effect of the overcast as the condition of the snow cover rapidly changes and, what is more important, that change cannot always be controlled. Certain qualitative conclusions can be made, however, on the effect of the overcast condition on the spectral albedo of the snow. Fig. 4 shows the average curves representing a spectral albedo over several days with a high overcast or cloudless sky but a heavy haze. In all cases the snow was dry and pure but somewhat different in structure. The data in Fig. 4 can be compared with the results cited in Fig. 1 from the point of view of the snow-cover condition. Such a comparison shows that the appearance of clouds or haze involves a considerable change in the relationship between the albedo and the wave length. The "two-humped" curves of Fig. 4 are quite different from those of Fig. 1. The appearance of high clouds apparently reduces the albedo in the direction of the shortest and longest waves and produces two maxima in the intermediate regions of the spectrum. Such an albedo-wavelength dependence is apparently quite characteristic but not the only one. The diversity of the albedo distribution in the spectrum under an overcast, just as in the case of a cloudless sky (Fig. 2), is very great. The data in Fig. 5 can serve as an example of the variability of the "unit" curves of the spectral albedo under a continuous medium and low overcast.

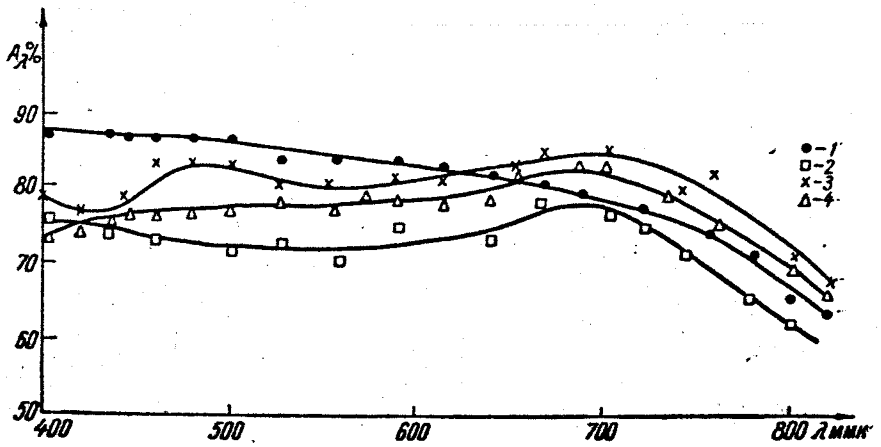


Fig. 5. The relationship between the snow albedo and the wavelength under a continuous medium and low overcast. Pure, dry, compact and fine-grained snow.

1 - 9:20 am, 10/0; 2 - 1:00 pm, 10/0; 3 - 3:00 pm, 10/0; 4 - 4:00 pm, 10/10 March 26, 1958.

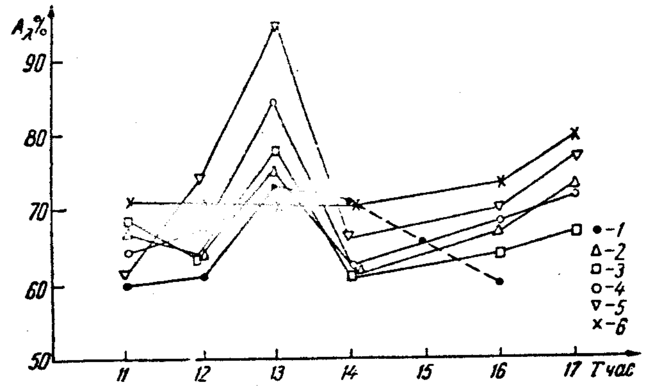
Let us take a look at the results characterizing the daily pattern of the spectral and integral albedo of the snow. The daily condition of the spectral snow albedo is determined by a complex and almost indivisible interaction of two factors: the changing condition of the snow cover and angular distribution of the total radiation (in the case of direct solar radiation, the change in the height of the sun is of first rate importance). The above-cited material prompts the conclusion that the daily condition of the spectral snow albedo is very complicated and varies with the observation conditions. By the same token, the integral snow albedo is also characterized by a considerable (but not lesser) daily variability.

A characteristic feature of the curves representing the daily condition of the spectral snow albedo is their fluctuation, the presence of several extremes (Fig. 6, 7). A monotonic relationship between the albedo and the height of the sun is not observable even under a cloudless sky (Fig. 6). Unfortunately it is impossible to compare the curves of the integral spectral albedo shown in Fig. 6, 7, inasmuch as our measurements extend to the 0.40-0.85 micron region of the spectrum while the integral albedo applies to the 0.4-2.4 micron region of the spectrum.

In this particular case, the small amplitude of the daily change of the integral albedo can be explained only by examining the results in the infrared region of the spectrum.

It should be pointed out, according to our data, that the results indicated in Fig. 6 and 7 are most characteristic. But some individual cases may present a different picture.

A recapitulation of the above justifies the assertion that the spectral albedo of the snow is highly variable in relation to the condition of the snow cover and the lighting conditions. The variability of the snow albedo in relation to the wavelength and time is very complicated, and cannot be explained with any certainty without a thorough



[час = hour]

Fig. 6. The daytime conditions of the spectral snow albedo on March 28, 1958. Fresh and loose snow.

1 - 400 mmc (millimicron); 2 - 501 mmc; 3 - 615 mmc; 4 - 687 mmc; 5 - 742 mmc; 6 - integral albedo, overcast 2/0.

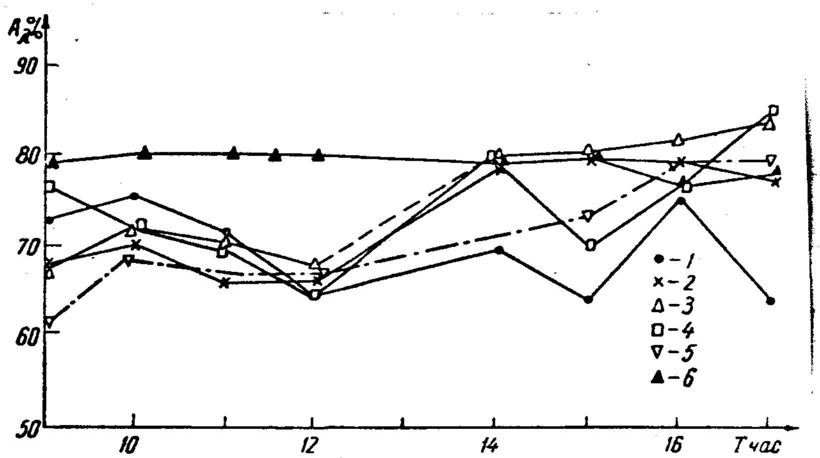


Fig. 7. The daytime condition of the spectral snow albedo on March 18, 1957. Fresh, pure and fine-grained snow.

1 - 400 mmc (millimicron); 2 - 500 mmc; 3 - 640 mmc; 4 - 687 mmc; 5 - 742 mmc; 6 - integral albedo, overcast 10/0.

investigation of the physical properties and condition of the snow cover. A simultaneous investigation of the spectral albedo and the snow cover condition is therefore a matter of great importance.

It is important to point out that the selective radiation reflection by the snow in the spectral region under study is not very prominent. The spectral composition of the radiation therefore remains practically unchanged as a result of its reflection from the snow cover. Shown in Fig. 8, a and b, for purposes of comparison are the energy

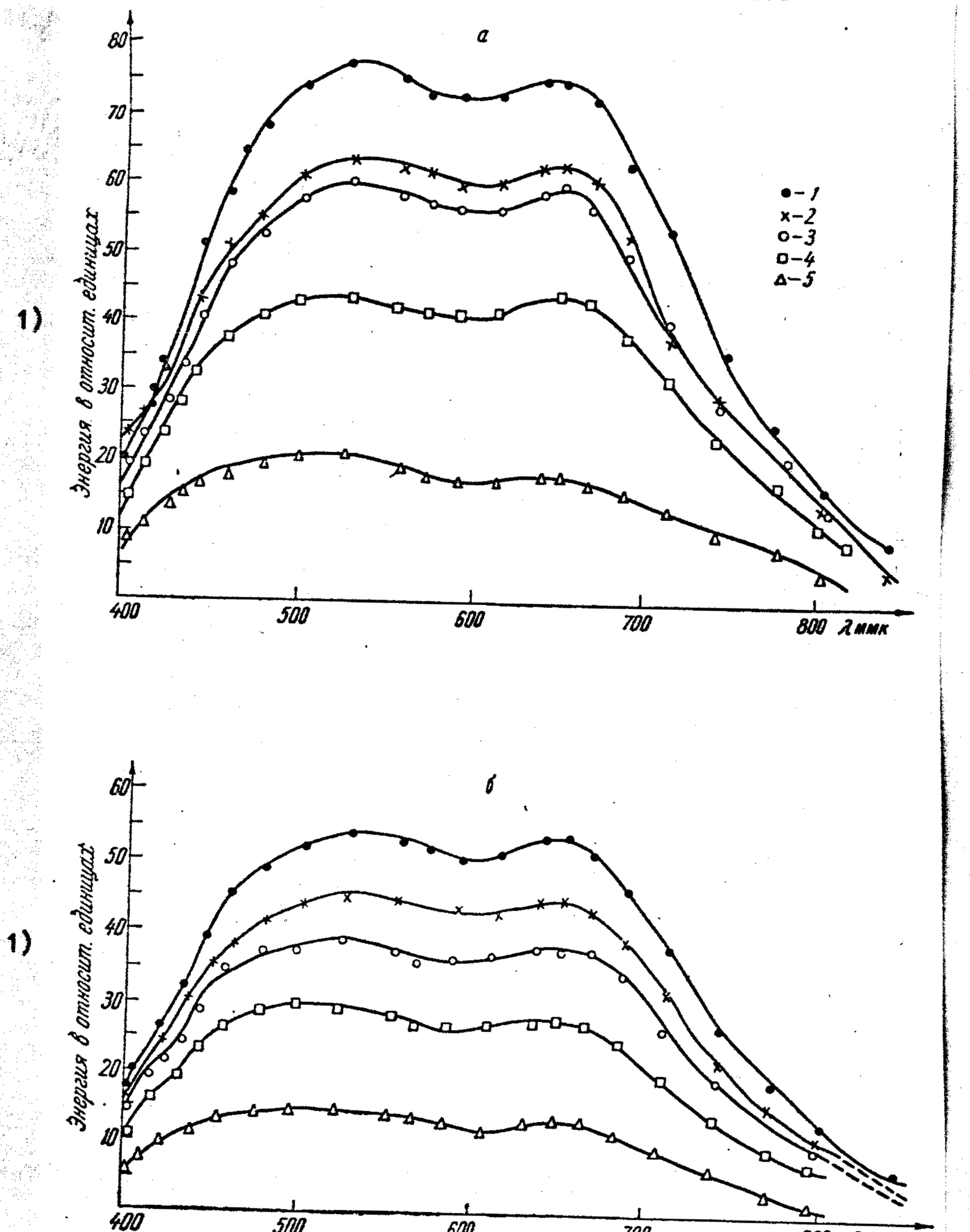


Fig. 8. Energy distribution. a - in the spectrum of the incident total radiation on March 4, 1957; b - in the spectrum of radiation reflected from the snow surface on March 4, 1957.

1 - 12:00 noon; 2 - 1:00 pm; 3 - 2:00 pm; 4 - 3:00 pm; 5 - 4:00 pm

Legend: 1) Energy in relative units.

distribution curves in the spectrum of total and reflected radiation based on observations of dry and pure snow under a cloudless sky and a haze under fleecy clouds (these data are preliminary). The two curve systems shown in this figure are apparently completely similar. Thus the spectral composition of the radiation in this case is practically unchanged by the reflection.

2. The Vegetative Cover

Unlike the snow cover the reflecting power of the vegetative cover has been investigated fairly thoroughly.

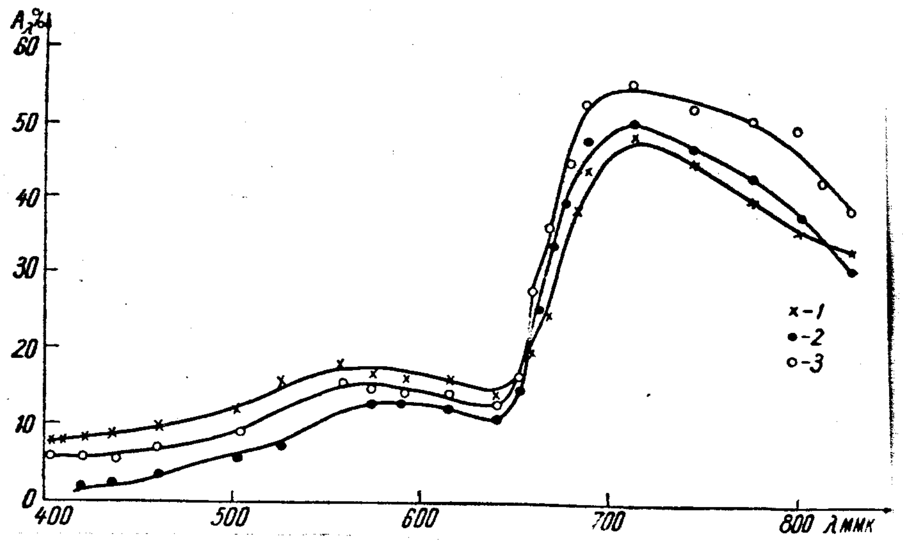


Fig. 9. The relationship between the grass albedo and the wavelength. February 19, 1956. Karadag.
1 - 3:00 pm; 2 - 4:00 pm; 3 - 5:00 pm, overcast 0/0.

Numerous measurements of the spectral brightness of various vegetative covers were made by Ye. L. Krinov [5]. Interesting data on similar laboratory measurements may be found in [7]. The use of light filters for measuring purposes [1] has produced a large number of different results. The figures on the spectrophotometric measurements of the albedo of natural vegetative covers were first cited in work [3].

The results of all the mentioned investigations show that low albedo values are characteristic of different types of green plants (succulent grass cover, green tree leaves, etc.) in the visible region of the spectrum with a small maximum in the area of 500-550 millimicron and a minimum in the chlorophyl absorption band (about λ = 650 millimicron). The albedo is greatly enhanced at a wavelength about 700 millimicron. According to [7], the albedo retains its high magnitude up to a wavelength of about 1 micron. When the vegetation turns yellow, the minimum reflection in the region of chlorophyl absorption is no longer observable. Our observations revealed the same general picture, the only notable difference being an indication of the existence of a clearly definable maximum albedo in the wavelength range of 770-800 millimicron. This can be judged from Fig. 9 which shows the results of three series of measurements of the albedo of fresh, succulent Sudan-grass based on observations under a cloudless sky. It is difficult to say why we previously failed to note this clearly discernible maximum reflection of the green vegetative cover in the longwave region. This apparently could not be done in [7] because the measurements had been made under laboratory conditions. As for Ye. L. Krinov's work [5], it is possible that the methods of determining the coefficients of the spectral brightness in the near infrared region of the spectrum used in that work were not sufficiently reliable.

A close analysis of Ye. L. Krinov's data shows, however, that in some cases the curves of the spectral albedo of green plants have a tendency to decline at a wavelength of about 800 millimicron. Observations made with light filters also failed to reveal any decrease in the albedo in the longwave region. The principal reason in this case was apparently the inadequate resolving power of the light filters.

An indirect confirmation of our conclusions about the maximum reflection in the shortwave portion of the near infrared region of the

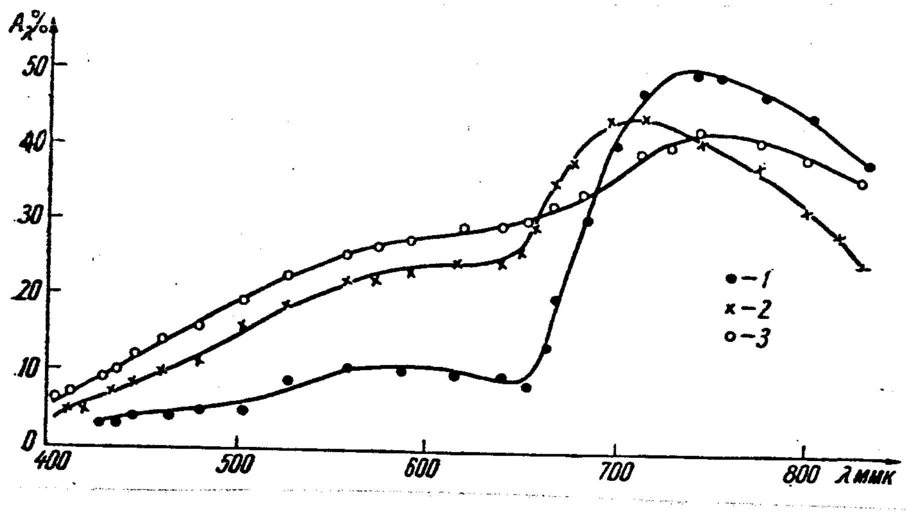


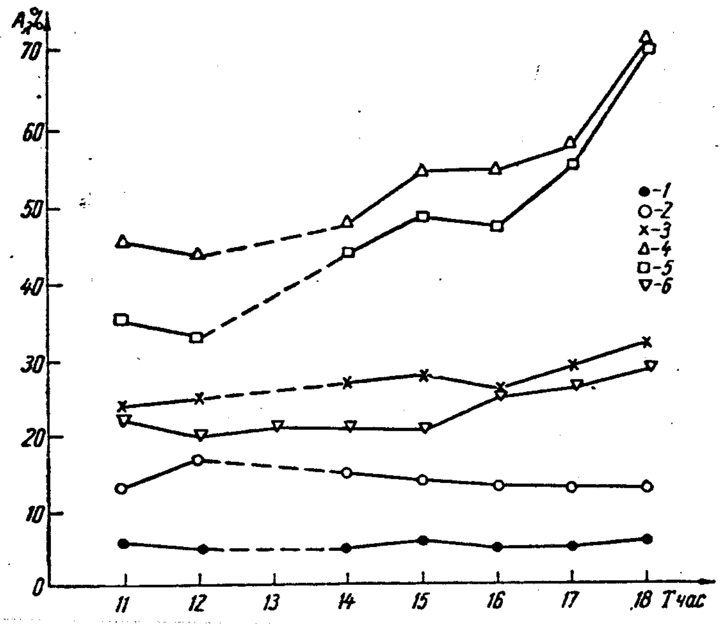
Fig. 10. The relationship between the albedo of the barley field surface and the wavelength in various stages of vegetation.

1 - green barley on June 20, 1956; 2 - yellow barley on July 4, 1956; 3 - barley stubble on 28 June, 1956, overcast 0/0.

spectrum can be found in V. I. Matulyavich in his work [8] in which the integral albedo was measured by a Yanishevskiy pyranometer and the albedo in the visible region of the spectrum by a selenium cell. According to [8], the albedo of the vegetative cover in the visible region of the spectrum is considerably higher than the integral albedo. This would be impossible with a high albedo magnitude in a wide interval of the near infrared region of the spectrum, as revealed in [7], and it thus provides an additional argument against the possibility of applying the laboratory data [7] to natural conditions. A marked decrease in the spectral coefficient of the brightness of a large number of plants between 800-900 and 1,200 millimicron was revealed in a recent work by M. L. Perevertun [9].

It is interesting to trace the evolution of the reflecting power of vegetative covers under changing vegetation phases. Fig. 10 shows such an evolution on a barley field. That example is quite indicative as the other vegetative cover reveal a similar picture. A close look at Fig. 10 shows that as the barley turns yellow the minimum reflection disappears from the region of chlorophyl absorption, and that the albedo in almost the entire spectral region under investigation is further enhanced. A further gradual increase in the albedo in the direction of long waves occurs in the case of barley stubble.

No study has as yet been made of the daily conditions of the spectral albedo of vegetative covers. It is known that the integral albedo of vegetation as a rule increases with the decreasing height of the sun. But no data are available on such a change of the spectral albedo. Our measurements serve to confirm the known patterns of the daily progress of the integral albedo, and for the first time facilitate an analogical analysis of the spectral albedo pattern. We hasten to point out, however, that the daily progress of the spectral albedo is considerably more complicated and variable.



[час = hour]

Fig. 11. The daytime condition of the spectral and integral albedo of barley on July 4, 1956.

1 - 417 mmc (millimicron); 2 - 500 mmc; 3 - 640 mmc; 4 - 712 mmc; 5 - 800 mmc; 6 - integral albedo, overcast 0/0.

Fig. 11, for example, shows the daily progress curves of the spectral and integral albedo based on the same observations of barley. An examination of Fig. 11 reveals that the albedo differs in various sections of the spectrum. The albedo in the region of the longest waves increases with the decreasing height of the sun. No monotonic relationship between the albedo and the height of the sun is observable in the other sections of the spectrum. A comparison of the curves representing the daily progress of the integral and spectral albedo prompts the conclusion that the daily progress of the integral albedo is apparently determined by the changing albedo in the near infrared region of the spectrum under the effect of the sun's height.

The data cited in Fig. 11 are the only individual examples of the observable patterns. For example, the albedo in the near infrared region of the spectrum occasionally decreases with the decreasing height of the sun, and a similar daily progress of the albedo is observable in the case of short waves. The latter fully agrees with the results of V. I. Matulyavich's observations [8] which revealed a decreasing albedo in the visible region of the spectrum with the decreasing height of the sun.

The analysis of the spectral albedo of vegetative covers failed to take into account the possible effect of the lighting conditions. The reasons for that is that in this case the effect of the lighting conditions is not as essential as in the case of the snow cover. The basic features of the relationship between the albedo of the vegetative covers and the wavelength remain unchanged under any light conditions. As for the patterns of the daily progress of the spectral albedo, they are subject to greater changes. We must accumulate further observation materials, however, in order to make the conclusions on this point very definite.

The object of our next investigations of the spectral albedo is to accumulate more materials and develop a set of instruments designed to measure the albedo in the region of longer waves.

We should point out in conclusion that only a small portion of the observation materials are cited in this text with a view to illustrating certain conclusions. A more complete summary of our observation results is provided in the supplement (See appendices 1, 2, 3).

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Appendix 1.

The measurements of the spectral albedo of the snow surface. Koltushi (Leningrad oblast), March 1957.

59°57' northern latitude
30°42' eastern longitude

Date	Mean Solar Time hrs.	min.	Cloudiness	Condition of Snow Cover *	400	403	410	420	435	445	460	480	501	526	557	572	590	615	640	652	667	687	712	742	775	800	Integral albedo
					Wavelength (millimicrons)																						
4 III	11	00	0/0	(1) Снег плотный, чистый, крупнозернистый	80	82	83	80	78	78	76	74	73	73	72	70	70	69	67	67	68	70	70	74	74	—	80
	12	00	0/0	(2) То же	61	71	77	78	79	77	79	—	—	70	71	—	69	7.	73	71	72	74	72	—	75	79	78
	13	00	0/0	"	68	73	78	79	77	76	74	76	73	71	71	70	73	72	73	72	73	73	74	76	77	79	77
	14	00	0/0, turbidity per ⊙	"	—	73	77	77	72	71	71	69	66	65	65	64	65	66	65	65	66	68	65	70	76	78	81
	15	00	0/0—1/0 Ci about ⊙	"	—	62	66	67	68	71	70	70	69	67	67	—	65	—	65	—	64	—	63	62	—	62	78
	16	00	5/0—10/0 Ci about ⊙	"	—	—	61	65	68	68	73	73	70	70	71	74	—	—	74	—	—	71	—	67	—	65	70
	17	00	5/0—Ci per ⊙	"	—	66	68	68	70	71	72	72	74	76	76	—	—	73	73	—	—	75	—	70	—	63	69
5 III	9	50	10/0 Ci, Ac, ⊙ at Ci	(3) Плотный, чистый, крупнозернистый, вчерашний	65	67	63	64	61	61	62	61	61	61	61	62	63	63	64	66	67	69	71	67	—	60	77
	11	00	10/0 Ac, As, ⊙ at Ac	(2) То же	70	71	72	72	73	75	75	76	77	77	78	78	78	78	79	78	78	78	77	75	—	79	79
	12	00	10/0 Ac	"	67	70	77	67	63	66	69	—	—	74	—	60	—	71	—	—	—	68	—	67	—	—	76
6 III	12	45	10/0 As, Cs, halo	(4) Свежевыпавший, сухой, рыхлый	83	—	—	77	—	—	—	79	—	73	—	—	—	78	—	—	—	68	—	69	—	—	82
	13	15	10/0 As, Cs, halo	(2) То же	—	85	83	80	80	80	79	79	78	77	80	—	83	82	80	82	—	81	—	81	—	80	80
	14	00	10/0 Cs, halo	"	72	77	80	80	83	83	83	82	83	84	84	—	83	84	83	—	85	—	90	98	—	98	78
	15	00	10/0 Cs, "	"	—	73	—	80	—	80	—	73	—	76	—	73	—	—	76	—	—	81	—	—	—	—	82
	16	00	10/0 Cs, "	"	81	79	—	—	—	71	—	76	—	—	—	—	—	—	65	—	—	—	—	81	—	—	81
	17	00	10/0 Cs, "	"	—	76	73	73	73	74	71	70	68	66	64	62	—	63	67	—	—	67	—	69	—	—	78
7 III	9	20	0/0, turbidity	(5) Снег рыхлый, сухой, мелкозернистый, вчерашний	77	80	82	80	79	80	78	78	77	76	76	75	—	75	75	—	76	77	—	77	—	77	73
	10	00	0/0, turbidity	(2) То же	73	78	78	86	84	81	78	78	76	75	75	73	—	73	71	—	69	69	—	70	—	69	76
	11	00	0/0, turbidity	"	—	79	83	80	78	76	76	76	74	74	73	72	—	70	68	—	69	66	—	68	—	68	76
	12	00	0/0	"	76	74	72	70	69	68	70	67	66	65	65	64	64	65	62	63	63	65	64	62	—	(60)	72
7 III	13	00	5/0 Ac—1/0 Ac	(5) Снег рыхлый, сухой мелкозернистый, вчерашний	72	73	74	71	75	—	74	74	75	75	74	—	77	77	77	—	—	79	—	72	—	(63)	76
11 III	9	30	10/10 Ns	(6) Снег сухой, загрязненный с темными пятнами после поземка, сырой	74	-	77	—	—	64	—	—	69	71	—	—	67	—	65	—	—	—	—	56	—	—	68

* For English text of entries in this column, please see page 23.

Date	Mean Solar Time hrs.	min.	Cloudiness	Condition of Snow Cover	Wavelength (millimicrons) 400	403	410	420	435	445	460	480	501	526	557	572	590	615	640	652	667	687	712	742	775	800	Integral albedo
11 III	10	15	10/10 Ns																								
	12	00	10/10 Ns	6 Снег сухой, загрязненный, с темными пятнами после поземка, сырой	64	52	56	62	53	53	54	49	45	44	49	—	47	46	50	—	58	56	—	67	—	—	72
	14	00	10/0 Ac, Ci	2 То же	69	68	—	69	67	—	67	—	—	53	60	—	—	—	61	—	—	—	—	—	—	—	73
	15	00	10/0 Ac	"	55	56	54	63	62	62	55	57	59	60	59	—	59	58	60	—	58	59	—	70	—	67	68
	16	00	10/0 Ac	"	—	—	—	—	50	52	40	42	60	—	53	—	—	—	54	—	—	52	—	—	—	—	63
14 III	9	50	10/0 Ac, Sc	"	—	56	59	58	68	71	66	56	78	68	—	—	—	60	51	—	—	76	—	68	—	—	73
	11	00	10/0 Cs, halo	7 Снег залежалый, темный, плотный с мелкозернистой корочкой, поземок	61	—	67	—	66	—	70	—	66	65	67	—	66	—	68	—	68	56	—	57	—	—	69
	12	00	10/0 Sc, Ac	2 То же	61	—	68	69	63	63	64	—	61	61	63	—	6[illegible]	—	67	—	66	58	—	74	—	—	72
	13	00	10/0 Sc, As	"	63	—	77	73	62	64	69	68	67	67	67	—	77	—	78	—	82	85	—	—	—	—	68
	13	10	10/10 As, Ns	"	61	—	65	75	65	65	66	69	70	72	75	—	79	—	83	—	88	—	—	—	—	—	69
17 III	10	00	1/0 Ci	"	57	—	60	64	70	72	72	72	73	73	74	—	75	—	72	—	74	74	—	62	—	68	71
	11	00	10/0 Cc	8 Снег чистый, мелкозернистый, плотный, с пятнами старого снега	65	65	66	64	62	61	61	62	62	61	61	—	60	60	61	—	59	58	—	61	—	70	71
	12	00	10/0 Cc, Ac	2 То же	69	—	68	65	62	63	62	62	62	62	62	—	63	63	65	—	64	65	—	65	—	65	69
	13	00	10/0 Cc, As	"	61	—	63	74	60	60	60	60	63	62	62	—	66	66	65	—	—	67	—	70	—	—	68
	15	00	2/0 As—7/0 As	"	75	—	67	—	67	—	69	—	68	68	—	—	68	—	71	—	—	76	—	—	—	—	70
	16	00	10/0 As, Cs, ⊙ As	"	59	58	59	60	60	61	60	65	68	—	—	—	67	—	69	—	—	63	—	75	—	—	70
	17	00	7/0 As	"	60	75	65	73	77	73	73	68	71	74	73	—	73	75	75	—	—	—	—	—	—	—	66
18 III	9	00	10/0 Ci, на ⊙ Ci	"	72	—	71	—	72	—	—	80	77	76	76	—	—	78	79	—	—	64	—	67	—	—	67
	10	00	10/0 Cs, Ci, halo	9 Снег свежевыпавший, чистый, мелкозернистый, волнистая поверхность после метели	73	—	71	—	69	—	—	68	68	68	—	—	68	—	68	—	—	77	—	62	—	—	79
	11	00	10/0 Cs, Ci, halo	2 То же	76	—	74	—	72	—	69	—	70	71	73	—	71	—	72	—	—	72	—	70	—	—	80
	12	00	10/0 Ci, halo	"	72	—	70	—	68	—	68	—	66	68	68	—	68	—	71	—	—	70	—	67	—	—	80
	14	00	10/0 Cs, As, halo	"	65	—	71	—	68	69	69	68	66	69	68	—	70	69	68	—	72	60	—	68	—	—	80
	15	00	10/0 Cs, halo	"	70	—	79	—	78	78	77	76	78	79	77	—	81	78	80	—	82	80	—	71	—	—	79
				"	64	—	70	—	76	79	79	81	80	79	80	—	80	78	80	—	81	70	—	74	—	—	80

Date	Mean Solar Time hrs.	min.	Cloudiness	Condition of Snow Cover	Wavelength (millimicrons) 400	403	410	420	435	445	460	480	501	526	557	572	590	615	640	652	667	687	712	742	775	800	Integral albedo
	16	00	10/10 As, Ns	(9) Снег свежевыпавший, чистый, мелкозернистый, волнистая поверхность после метели .	76	—	77	76	78	80	82	78	79	82	81	—	82	83	82	—	76	77	—	79	—	—	77
	17	00	10/0 As	(2) То же	64	—	66	82	78	—	—	74	77	80	81	—	83	82	84	—	—	85	—	74	—	—	78
20 III	11	00	0/0	(10) Снег сухой, плотный, залежалый, волнистая поверхность, чистый	67	—	72	73	72	73	72	72	72	70	70	69	68	68	71	—	73	73	—	—	—	—	77
	12	10	0/0, haze	(2) То же	69	—	72	72	70	—	70	70	70	70	70	—	—	70	70	—	—	71	—	66	—	—	77
	13	10	0/0, turbidity	"	64	—	67	71	72	74	72	71	70	71	72	—	72	72	73	—	73	74	—	86	—	—	79
	14	00	0/0 "	"	61	—	66	71	69	68	67	68	69	69	73	—	77	73	72	—	—	73	—	(90)	—	—	80
	15	00	0/0 "	"	68	—	75	80	75	71	71	69	70	67	67	—	70	68	72	—	74	75	—	(74)	—	—	75
	16	00	0/0	"	68	—	75	77	68	71	74	72	67	68	72	—	73	75	73	—	72	63	—	(71)	—	—	75
	17	00	0/0, darkness	"	74	—	75	74	79	72	77	75	76	74	77	—	77	77	71	—	75	80	—	(89)	—	—	74
21 III	10	00	10/0 Ac, Cs, Ci	(11) Снег залежалый, плотный, вчерашний, сухой	68	—	70	70	74	72	72	72	72	72	75	—	72	—	72	—	70	71	—	74	—	—	76
	11	00	10/0 Ac	(2) То же	72	—	76	73	75	73	73	76	72	74	75	—	76	74	77	—	70	71	—	77	—	—	79
	12	00	10/0 Ac, Cc	"	70	—	72	—	73	70	70	70	71	71	73	—	72	72	75	—	73	72	—	77	—	—	76
	14	00	10/0 Ac, As	"	76	—	80	78	76	77	77	77	76	76	76	—	—	77	78	—	79	73	—	81	—	—	75
23 III	10	45	0/0	(12) Снег свежевыпавший, тонкий слой, рыхлый, сухой . . .	75	—	80	81	80	80	80	80	80	81	78	—	80	89	89	—	90	90	—	—	—	—	83
	12	00	0/0	(2) То же	83	—	83	81	79	77	76	75	75	75	73	—	74	77	76	—	77	78	—	84	—	—	83
	13	00	1/1 Cu	"	—	—	—	89	83	81	79	77	76	75	75	—	73	72	73	—	73	75	—	82	—	—	82
	14	00	0/0	(13) Снег свежевыпавший, тонкий слой, рыхлый, сухой, слабый поземок	68	—	68	67	68	68	60	64	69	70	—	—	—	—	—	—	68	70	—	76	—	71	80
	14	15	0/0	(2) То же	—	—	79	78	76	71	69	67	66	69	66	—	64	63	62	—	60	58	—	51	—	—	80
	15	00	0/0, traces of Cu	(12) Снег свежевыпавший, тонкий слой рыхлый, сухой	—	—	61	63	—	66	65	64	63	62	56	—	60	62	60	—	49	46	—	—	—	—	82
	16	00	0/0	(2) То же	60	—	62	64	65	66	66	70	66	65	64	—	63	60	67	—	67	69	—	71	—	—	80
	17	00	0/0	"	—	—	—	54	58	58	59	60	60	60	60	—	61	61	63	—	63	68	—	71	—	—	77
24 III	9	00	0/0	(14) Снег вчерашний, сухой, мелкозернистый, волнистая поверхность	—	—	65	78	82	87	86	84	84	80	82	—	82	81	83	—	83	81	—	(72)	—	—	87
	10	00	0/0	(2) То же	74	—	79	79	79	77	78	79	79	80	80	—	81	80	80	—	80	86	—	(74)	—	—	88
	11	00	1/0 Ci	"	68	—	73	75	74	75	75	75	75	75	75	—	74	75	76	—	76	76	—	76	—	—	80
	12	00	1/0 Ci	"	58	—	60	65	66	67	68	68	68	69	68	—	70	72	70	—	70	70	—	73	—	—	84
	13	00	2/0 Ci	"	70	—	74	77	74	74	72	71	71	71	72	—	73	74	71	—	72	70	—	—	—	—	83
	15	00	10/0 Ci	"	67	—	66	67	67	68	66	68	65	61	68	—	68	66	62	—	66	65	—	66	—	—	80
	16	00	10/0 Ci	"	—	—	—	52	54	55	55	57	55	54	51	—	51	50	49	—	48	54	—	(59)	—	—	81

Column 4 - CONDITIONS OF SNOW COVER

(English text of Russian entries)

1. Compact, pure & large-grained snow.
2. Ditto.
3. Compact, pure, large-grained, day-old snow.
4. Fresh, dry & loose snow.
5. Loose, dry, fine-grained, day-old snow.
6. Dry & impure snow with dark patches after a drift, wet.
7. Stale, dark & compact snow with a fine-grained crust, drift.
8. Pure, fine-grained & compact snow with patches of stale snow.
9. Fresh, pure & fine-grained snow, rolling surface after snowstorm.
10. Dry, compact & stale snow, rolling surface, pure.
11. Stale, compact, day-old and dry snow.
12. Fresh, loose & dry snow, thin layer.
13. Fresh, loose & dry snow, thin layer, slight drift.
14. Day-old, dry & fine-grained snow, rolling surface.

Measurements of the spectral albedo of the snow surface. Sablino (Leningrad oblast)
February-March 1958

$59^{\circ}40'$ latitude
$30^{\circ}48'$ longitude

Date	Mean Solar Time hrs.	min.	Cloudiness	Condition of Snow Cover *	400	403	410	420	435	445	460	480	501	526	557	572	590	615	640	652	667	687	712	792	775	800	Integral albedo
					Wavelength (millimicrons)																						
7 II	11	15	0/0, haze	(1) Снег чистый, свежевыпавший, рыхлый . . .	74	74	77	76	—	—	79	73	72	81	80	—	88	—	—	—	82	—	65	69	—	60	—
	14	00	10/3 As, Fc	(2) То же . . .	—	74	79	76	—	66	83	63	74	64	70	—	74	58	73	—	—	—	68	65	—	72	—
	15	00	10/4 As, Sc, Fc	. . .	80	89	81	78	75	75	73	73	71	71	72	—	72	72	71	79	72	—	66	70	—	—	—
11 II	11	00	2/0 Sc	(3) Снег плотный, чистый, мелкозернистый, сухой . . .	—	78	71	75	75	74	74	75	77	76	76	75	76	74	75	76	76	75	71	65	68	64	77
	15	00	0/0	(2) То же . . .	82	85	77	74	75	65	72	70	60	64	66	66	60	68	81	77	73	69	61	71	78	—	89
	16	00	3/0 Ci	. . .	71	76	78	82	78	75	74	75	76	77	65	67	69	68	67	73	73	78	67	67	—	—	74
25 II	10	00	8/0 Ci	(4) Снег сухой, мелкозернистый, чистый . . .	74	75	72	72	63	63	62	62	62	63	64	61	60	60	60	60	64	64	65	69	72	—	—
	11	00	5/0 Ci	(5) Снег сухой, мелкозернистый, чистый, поземок . . .	74	63	59	51	71	67	70	73	71	66	60	67	68	77	75	59	67	66	73	—	59	65	—
	12	00	2/0 Ci	(6) Снег сухой, мелкозернистый, чистый, поземка нет . . .	63	67	70	67	70	71	70	69	69	68	69	69	71	74	75	79	78	77	78	78	77	73	—
	13	00	0/0	(2) То же . . .	68	69	69	67	67	66	66	65	65	65	64	63	63	62	62	61	61	60	60	60	59	60	—
	14	00	1/0 Ci	. . .	76	78	75	79	77	76	75	78	81	86	88	—	—	—	—	—	—	71	69	74	70	62	—
	15	20	0/0	. . .	68	72	70	71	69	68	68	68	67	66	66	67	68	69	73	73	74	70	62	55	53	53	—
	16	00	1/0 Ci	. . .	69	70	69	70	67	63	59	61	60	59	57	57	57	58	61	68	73	77	83	84	82	76	—
26 II	8	20	10/0 Cs, As	(7) Снег залежалый, плотный, сухой, мелкозернистый . . .	89	87	87	87	87	87	87	87	87	84	84	84	84	83	82	81	81	80	75	76	77	—	—
	9	20	10/0 Cs, As	(2) То же . . .	82	82	78	78	72	74	79	78	80	81	81	80	81	85	86	—	—	76	76	72	72	74	—
	12	00	10/0 As	. . .	74	69	73	74	74	74	73	73	75	74	70	—	75	74	72	87	81	81	79	—	—	—	—
	14	00	10/10 St	. . .	—	—	—	76	76	80	85	81	83	75	78	83	83	82	82	82	85	80	87	80	85	—	—
	15	00	10/10 St	. . .	74	75	75	74	75	77	77	77	77	79	78	78	82	79	78	81	—	81	86	—	—	—	—
4 III	9	00	0/0, haze	(8) Снег сухой, плотный, мелкозернистый . . .	71	76	77	73	72	72	73	73	73	73	74	75	74	75	75	74	72	72	73	72	72	72	—
	12	00	2/0 Ci	(2) То же . . .	—	—	54	52	52	54	57	60	59	59	60	60	60	61	62	61	62	61	63	60	63	—	—
	13	00	4/0 Ci	. . .	—	—	51	62	72	75	72	73	67	65	52	55	53	42	46	50	51	52	55	56	52	53	—
	14	00	3/0 Ci	. . .	58	60	62	62	62	58	57	56	55	54	54	53	58	59	61	61	62	62	58	57	57	59	—
	16	00	9/0 Ac	. . .	65	69	69	70	72	72	72	73	73	74	73	73	72	72	72	74	77	83	82	77	76	72	—
8 III	12	00	1/0 Ci	(9) Снег свежевыпавший, рыхлый, уплотняется от нагрева солнцем . . .	65	63	63	65	64	64	71	70	69	69	67	66	65	61	61	58	57	58	57	57	56	54	74
17 III	8	30	0/0	(10) Снег загрязненный, сырой, уплотненный . . .	—	—	—	55	56	59	67	65	65	67	67	68	68	68	70	72	69	67	67	63	64	—	—
	10	00	0/0	(2) То же . . .	58	62	65	72	70	70	69	55	55	55	51	53	64	66	63	—	—	65	62	64	60	60	70
	11	00	0/0	. . .	61	65	63	63	63	68	66	65	64	65	65	66	63	64	65	65	67	67	63	65	61	66	70
	12	00	0/0	. . .	63	65	66	69	69	68	68	66	65	65	65	65	65	64	64	63	69	72	75	77	77	—	70
	14	00	0/0	. . .	63	57	57	60	61	62	62	63	66	64	64	64	64	63	63	63	66	67	68	70	70	—	69

* For English text of entries in this column, please see page 28.

Appendix 2 - cont.

Date	Mean Solar Time hrs.	min	Cloudiness	Condition of Snow Cover	400	403	410	420	435	445	460	480	501	526	557	572	590	615	640	652	667	687	712	792	775	800	Integral albedo
17 III	16	00	0/0	10 Снег загрязненный, сырой, уплотненный	57	61	62	64	67	68	69	75	75	73	73	72	72	72	72	72	77	78	80	80	78	—	71
	17	00	0/0	2 То же	63	65	65	67	65	69	82	—	81	80	80	74	76	77	80	81	81	81	81	83	86	—	72
18 III	14	00	1/0 Ci	11 Снег загрязненный, сырой	75	75	71	71	66	64	62	63	63	63	61	60	59	57	59	61	60	64	60	58	54	58	70
	16	00	1/0 Ci	2 То же	67	69	68	70	71	73	75	81	78	76	74	72	71	63	69	70	69	66	62	73	87	80	73
	17	00	0/0	12 Снег загрязненный, сырой, замерзает	60	65	64	63	62	66	70	89	84	84	84	84	80	82	81	79	79	86	87	81	80	—	83
19 III	8	00	1/0 Ci	13 Снег загрязненный, твердый	67	71	69	69	69	68	68	63	65	65	63	63	64	65	73	72	70	68	65	63	62	62	69
	9	00	0/0	2 То же	58	62	61	63	64	66	67	71	69	68	68	68	68	67	67	70	71	71	71	69	69	62	68
	11	00	2/0 Ci	•	72	71	70	68	68	67	66	68	67	66	66	65	65	65	64	68	70	70	71	75	74	73	69
	12	00	1/0 Ci	•	63	63	64	64	63	62	63	66	64	64	64	64	63	63	62	62	60	59	58	58	59	62	69
	13	00	2/0 Ci	•	57	61	61	64	63	63	63	64	63	62	63	64	64	64	65	66	68	70	69	74	74	74	69
	14	00	5/0 Ci	•	59	64	62	63	62	60	60	62	62	62	61	62	62	61	60	59	59	58	57	55	58	61	69
	16	00	9/0 Ci	•	59	60	61	64	65	67	68	75	75	74	74	73	70	71	71	75	77	78	79	82	80	73	73
	17	00	9/0 Ci	•	59	64	63	63	64	66	67	69	68	69	67	66	66	66	64	63	59	58	54	65	66	68	76
21 III	8	20	0/0	14 Снег сухой, загрязненный, мелкозернистый	62	62	61	61	60	65	62	67	66	66	64	—	69	68	69	70	71	73	—	69	70	69	71
	10	00	0/0	2 То же	—	—	—	57	58	58	66	71	62	60	56	62	63	62	62	60	61	61	61	57	—	—	68
	11	00	0/0	•	53	59	61	61	62	62	65	63	61	62	62	63	62	68	69	70	71	73	76	76	77	70	69
	12	00	0/0	•	60	62	63	63	62	62	61	64	62	62	63	62	62	61	61	68	68	69	72	72	72	72	70
	14	00	0/0	•	52	57	61	64	64	65	65	65	66	67	68	67	67	66	65	64	63	63	69	70	70	67	68
21 III	16	00	0/0	•	60	61	63	63	61	63	74	76	73	68	68	67	67	63	66	71	66	68	72	71	71	—	73
	17	00	0/0	•	60	59	63	65	66	65	65	65	65	65	67	63	64	66	67	67	68	69	71	73	73	72	68
22 III	9	15	0/0	15 Снег сухой, залежалый, спрессовавшийся	60	63	65	67	68	68	69	69	69	69	68	68	67	67	68	67	67	66	65	63	65	65	67
	10	00	1/0 Ci	2 То же	57	56	56	58	60	61	62	61	62	62	61	61	61	69	67	67	66	64	63	64	68	—	68
	11	00	1/0 Ci	•	63	65	66	65	64	64	64	64	64	63	62	62	62	65	70	70	70	70	69	68	62	61	68
	12	00	1/0 Ci	•	60	62	64	62	63	63	64	69	69	68	69	68	68	68	68	66	66	69	71	70	68	65	69
	13	00	2/0 Ci	•	55	56	58	61	61	68	67	65	65	65	65	64	65	67	68	70	72	71	70	70	70	64	68
	16	00	0/0	•	60	59	61	62	64	65	66	76	72	72	67	66	65	64	63	63	65	68	71	74	71	61	71

Appendix 2 - cont.

Date	Mean Solar Time hrs.	min	Cloudiness	Condition of Snow Cover	Wavelength (millimicrons) 400	403	410	420	435	445	460	480	501	526	557	572	590	615	640	652	667	687	712	792	775	800	Integral albedo
28 III	11	00	2/0 Ac	16 Снег свежевыпавший, хлопкообразный (просвечивает залежалый снег)	60	63	64	66	65	65	65	66	67	68	68	67	68	68	68	67	67	64	62	62	61	62	72
	12	00	1/0 Ac	2 То же	61	64	63	63	62	63	63	64	64	64	64	64	64	64	64	66	66	67	69	74	72	70	71
	13	00	1/0 Cu	»	73	74	74	75	74	75	75	76	75	75	76	77	77	76	76	80	81	84	87	94	95	94	71
	14	00	0/0	»	71	69	67	62	61	60	61	62	61	61	60	61	61	60	60	59	60	62	64	66	68	66	70
	16	00	0/0	»	60	60	59	62	62	62	61	70	67	66	64	64	63	64	61	60	63	66	68	70	72	66	73
	17	00	0/0	»	—	—	46	57	59	62	67	75	73	71	70	68	67	67	69	—	64	72	76	77	76	71	80
29 III	9	20	10/0 Ac	17 Снег чистый, рыхлый	67	57	70	63	59	72	—	64	75	63	64	63	65	66	67	65	69	69	68	71	52	—	60
	10	10	6/0 Ac	2 То же	—	—	65	67	67	47	66	49	68	63	55	66	66	65	64	65	70	71	71	—	71	68	68
	12	20	5/0Ac—3/0 Ac	18 Снег чистый, рыхлый, сырой	70	72	70	69	69	70	69	71	72	72	73	76	80	80	80	82	82	82	83	82	84	87	69
	14	35	1/0 Cu	2 То же	59	60	59	62	61	60	67	66	65	65	65	65	65	65	65	66	65	63	58	61	61	64	68
	16	00	3/2 Cu, Ci—5/1 Ci, Cu	»	60	60	60	59	57	57	56	69	64	66	66	66	66	65	65	66	66	68	70	73	74	65	71
	17	00	5/2 Ci, Cu	»	64	67	67	63	66	69	72	75	72	70	70	68	68	66	65	62	64	67	68	66	58	56	—
31 III	7	50	0/0	19 Снег загрязненный, пористый, крупный	72	72	70	67	68	67	64	62	63	62	63	64	63	61	59	71	69	64	60	57	56	55	67
	9	00	0/0, turbidity	20 Снег загрязненный, пористый, крупный, сырой	65	64	64	68	64	67	66	61	60	59	62	67	59	58	55	55	53	—	58	65	59	—	63
	10	00	0/0, turbidity	2 То же	—	—	44	47	50	52	53	53	52	51	49	48	48	50	52	51	51	51	51	43	41	—	64
	11	00	0/0	»	54	63	61	60	59	55	57	59	59	59	58	59	59	59	58	63	64	66	66	67	66	—	66
	12	00	0/0	»	61	64	66	67	68	69	71	78	79	80	80	80	80	80	80	79	81	83	84	88	87	81	65
	13	00	0/0	»	75	75	74	74	70	73	75	72	72	74	75	77	78	77	74	72	72	73	74	77	79	71	63
	14	00	0/0	»	51	55	57	58	58	58	58	61	61	61	61	61	61	61	61	61	62	62	62	62	60	—	62
	15	50	0/0	»	50	51	52	53	55	64	56	66	65	66	67	67	67	67	67	63	60	68	72	73	74	—	64
	17	00	0/0	»	60	60	60	60	62	64	66	72	70	69	69	68	68	67	66	78	80	84	86	78	69	59	70
1 IV	8	00	2/0 Ci	21 Снег сухой, загрязненный, пористый, крупинками	65	63	62	64	63	65	65	61	62	63	63	63	64	63	65	64	63	62	60	58	60	56	66
	9	00	2/0 Ci	2 То же	61	59	57	52	52	53	52	63	62	64	64	64	62	67	68	62	62	62	61	61	58	—	63
	10	00	2/0 Ci	»	57	54	56	55	59	57	65	70	64	62	62	62	62	61	60	67	66	66	67	65	66	60	63
	11	00	3/0 Ci—5/0 Ci	»	55	57	57	54	54	55	70	64	64	64	64	65	65	65	64	65	67	69	71	73	74	73	62

Date	Mean Solar Time hrs.	min	Cloudiness	Condition of Snow Cover	Wavelength (millimicrons) 400	403	410	420	435	445	460	480	501	526	557	572	590	615	640	652	667	687	712	742	775	800	Integral albedo
1 IV	14	00	3/0 Ci	22 Снег более пористый, сырой, загрязненный	53	50	49	48	50	51	51	62	62	63	63	63	63	63	64	62	62	60	59	55	49	—	62
	16	00	2/0 Ci	2 То же	54	51	49	50	52	53	69	67	66	65	65	64	63	63	63	61	62	62	64	59	52	—	62
	17	00	3/0 Ci	.	56	56	57	59	60	62	63	76	75	75	75	75	75	74	74	71	75	77	77	71	66	55	65
	18	00		.	58	59	59	59	58	58	59	65	65	65	65	65	65	65	64	67	67	68	68	71	69	65	62
4 IV	8	00	1/0 Ci	23 Снег крупнокристаллический, загрязненный (наст)	61	57	66	64	56	60	61	64	64	64	63	64	63	62	60	62	59	58	56	55	53	56	57
	10	00	1/0 Ci	2 То же	64	63	62	57	56	65	58	60	59	59	59	59	59	59	59	61	62	60	62	60	60	—	52
	11	00	2/0 Ci	24 Снег мокрый, блеск капель воды	58	58	58	58	59	60	60	61	62	62	62	62	63	63	63	64	66	67	68	68	69	65	52
	12	00	1/0 Ci	24 Снег мокрый, блеск капель воды	61	60	59	59	59	59	59	60	60	61	61	62	[illegible]	62	62	62	63	63	65	66	67	61	51
	13	00	1/0 Ci	2 То же	54	58	61	64	67	68	69	73	73	75	75	75	76	77	77	79	82	83	84	89	86	79	51
	14	00	1/0 Ci	.	49	53	56	56	58	59	59	59	59	59	59	60	60	60	60	60	60	60	60	61	59	59	51
8 IV	8	00	0/0	25 Снег кристаллический, грязный, сходит, тонкий слой, сырой	51	55	59	59	60	61	63	75	74	74	74	74	73	72	70	73	76	79	79	80	80	80	52
	9	00	0/0	2 То же	58	57	57	62	62	63	62	56	55	54	55	58	59	59	59	73	76	82	87	89	82	78	51
	10	00	1/0 Ac	.	64	64	62	59	60	60	60	62	61	61	62	62	62	62	60	64	65	66	67	67	65	—	51
	11	00	5/0 Ac	.	55	56	60	62	62	60	61	63	58	60	62	63	62	63	63	63	61	60	59	59	60	60	49
	12	00	3/3 Cu	.	54	56	57	58	59	60	64	64	64	63	63	65	65	66	66	67	66	63	62	62	63	62	49
	14	00	8/8 Fc, Ac, Cb	.	45	51	60	—	48	56	—	—	—	—	52	—	—	—	56	—	54	—	57	—	55	60	53
	16	00	7/7 Cu, Fc	.	43	42	41	38	38	39	38	51	50	48	48	48	47	46	46	51	50	49	47	44	45	46	50
10 IV	10	00	4/0 Ci	26 Снег пористый, сырой с каплями влаги, грязный	53	52	50	51	53	54	53	57	56	55	54	54	55	54	56	52	52	51	56	—	55	51	—
	11	00	5/0 Ci—7/0 Ci	2 То же	55	55	55	57	58	—	61	54	55	57	57	58	57	59	—	61	62	69	65	64	57	—	—
	12	00	8/0 Ci, Cs, halo	.	52	52	56	55	56	55	51	57	56	57	57	54	54	57	53	59	59	61	61	62	60	—	53
	13	00	10/0 Cs, Ci, halo	.	51	56	55	55	53	53	53	58	58	58	59	58	58	57	58	58	59	61	65	63	65	60	58
	14	00	10/0 Cs, As, halo	.	55	56	55	53	56	54	54	60	57	57	56	57	58	57	57	59	60	61	60	63	66	60	59
	15	00	10/0 Cs, As, halo	.	50	51	52	58	56	—	56	62	61	59	59	58	59	58	57	61	62	64	64	64	—	59	57
	16	00	10/0 Cs, As	.	50	53	53	56	57	58	59	61	61	61	60	60	60	63	59	62	60	63	63	61	58	53	—
	17	00	10/0 Cs, As	.	50	50	51	54	56	58	59	65	64	64	64	63	63	61	60	64	66	67	68	69	66	59	66

Column 4 - CONDITIONS OF SNOW COVER

(English text of Russian entries)

1. Pure, fresh & loose snow.
2. Ditto.
3. Compact, pure, fine-grained & dry snow.
4. Dry, fine-grained & pure snow.
5. Dry, fine-grained & pure snow, drift.
6. Dry, fine-grained & pure snow, no drift.
7. Stale, compact, dry & fine grained snow.
8. Dry, compact & fine-grained snow.
9. Fresh & loose snow made compact by Sun's heat.
10. Impure, wet & compact snow.
11. Impure & wet snow.
12. Impure, wet & freezing snow.
13. Impure & hard snow.
14. Dry, impure & fine-grained snow.
15. Dry, stale & compact snow.
16. Fresh, cotton-like snow (stale snow visible through it).
17. Pure, loose snow.
18. Pure, loose & wet snow.
19. Impure, porous & coarse snow.
20. Impure, porous, coarse & wet snow.
21. Dry, impure, porous & granular snow.
22. Wet & impure snow with greater porosity.
23. Macrocrystalline & impure snow.
24. Wet snow, glittering snow drops.
25. Crystalline & impure snow, diminishing, thin layer, wet.
26. Porous & wet snow with moisture drops, impure.

Appendix 3.

Measurements of the spectral albedo of various surfaces. Karadag (Crimea), 1956.

$44^{o}54'$ northern latitude $36^{o}12'$ eastern longitude

Date	Mean Solar Time hrs.	min	Cloudiness	Surface *	400	403	410	412	417	420	428	435	445	460	480	501	526	557	572	590	615	640	652	667	687	712	742	775	800	830	Integral albedo
					Wavelength (millimicrons)																										
30 VII	13	00	0/0	1 Пляжная галька	16	15	15	16	17	17	18	19	21	21	22	23	26	28	28	28	28	27	26	25	25	23	22	20	20	—	15
	14	00	0/0	2 То же	—	12	12	13	14	14	13	15	17	18	19	20	23	24	25	25	25	25	25	26	22	21	18	16	15	—	15
	15	00	0/0		—	11	11	12	12	12	13	14	15	16	17	18	20	22	23	24	24	24	23	22	21	21	19	19	20	—	15
	16	00	0/0		13	13	14	13	13	12	13	14	14	14	15	16	18	20	20	21	22	22	22	21	20	19	17	18	18	19	15
	17	00	0/0		—	—	18	18	16	16	15	14	14	14	14	15	16	17	18	19	20	20	20	20	20	20	20	20	22	—	15
31 VII	8	00	0/0	1 Пляжная галька	—	—	12	12	13	12	13	13	14	16	17	18	19	22	23	24	25	26	26	26	26	25	24	24	24	22	—
	9	00	0/0	2 То же	—	—	13	14	13	14	15	15	16	17	17	20	21	24	25	26	26	27	26	26	26	24	24	24	22	22	—
	10	00	0/0		—	14	14	14	14	14	14	14	14	18	19	22	23	26	27	28	29	29	29	29	28	28	27	25	23	22	16
	11	00	0/0		12	12	12	12	12	12	13	13	15	16	18	19	21	24	25	26	27	29	30	26	26	25	24	24	21	20	16
	12	00	0/0		—	—	—	13	12	13	13	14	15	17	18	19	21	24	25	26	26	27	29	27	26	25	23	22	20	19	16
	14	30	0/0		—	—	14	14	14	14	15	15	16	17	18	19	20	23	24	25	26	27	26	25	27	27	26	28	26	19	15
	15	00	0/0		—	14	14	14	13	13	14	15	14	16	17	18	19	22	23	23	25	25	25	25	23	23	21	20	19	18	15
	16	00	0/0		10	11	12	13	12	12	13	13	13	14	15	16	18	20	21	22	23	23	23	23	22	22	21	20	19	19	15
	17	00	0/0		9	14	15	13	12	11	11	11	12	12	14	15	17	19	19	20	21	22	22	23	22	22	22	20	21	20	14
19 VI	15	00	0/0	3 Редкая сочная трава суданка (высота от земли 50 *см*), почва сухая	8	8	8	8	8	8	8	9	9	10	10	12	16	18	16	16	16	14	17	25	44	48	45	40	36	29	20
	16	00	0/0	2 То же	—	—	—	—	2	2	2	2	3	4	5	6	12	14	13	13	12	11	15	34	48	50	47	43	38	31	20
	17	00	0/0		6	6	6	6	6	6	6	6	6	7	6	9	15	16	15	14	14	13	17	37	53	57	52	51	50	39	22
	18	00	0/0		—	—	8	7	7	8	7	7	8	8	8	9	16	18	16	15	15	14	16	34	58	60	51	52	40	33	24
	19	00	0 0		—	—	—	9	8	11	11	10	9	6	7	8	14	15	13	9	9	8	10	24	49	56	58	54	42	27	30
23 VII	9	00	0/0	4 Трава редкая сочная суданка (высота 15—20 *см*), почва сухая	2	2	2	3	4	4	5	5	6	7	7	9	15	17	15	13	13	11	12	25	41	44	44	45	42	42	18
	10	00	1/1 Cu	2 То же	2	2	2	3	3	3	4	4	6	7	7	8	15	17	15	14	15	13	15	29	40	44	45	46	42	39	18
	10	50	0/0		2	3	3	3	3	4	5	5	5	6	7	8	15	18	17	17	16	14	16	30	45	46	46	42	37	35	18
	12	00	0/0		2	2	3	4	4	4	5	7	7	8	9	15	16	16	16	16	16	15	16	29	42	47	46	47	43	43	17
	13	00	2/2 Cu		3	3	3	4	5	5	5	6	5	8	9	10	16	17	16	16	16	14	15	26	43	48	48	51	52	50	18
20 VI	8	30	0/0	5 Ячмень в стадии колошения, высота 1 *м*	7	6	6	5	5	5	4	4	4	4	5	6	11	13	13	12	11	9	8	23	48	52	63	—	—	—	22
	10	00	0/0	2 То же	5	4	4	5	5	5	5	4	4	5	5	6	10	11	10	10	9	9	8	23	34	35	—	—	—	—	20
	11	00	0/0		—	—	—	—	2	2	2	2	3	3	4	4	9	11	11	11	10	9	9	18	36	42	46	44	40	32	18

* For English text of entries in this column, please see page 31.

Appendix 3 - cont.

20 VI	12	00	0/0	5 Ячмень в стадии колошения, высота 1 м	—	—	—	—	—	—	3	3	4	4	5	5	9	11	11	11	11	10	9	21	34	50	51	48	45	39	18
	13	00	0/0	2 То же	—	—	—	—	—	2	2	3	4	4	5	5	9	11	12	12	11	10	13	31	43	49	46	42	44	41	18
	14	00	0/0	»	4	4	3	3	4	5	4	4	4	5	5	8	12	13	12	12	11	10	14	34	51	54	50	44	38	32	19
	15	00	0/0	»	3	3	—	3	3	3	4	4	5	5	5	7	12	14	13	12	12	11	15	36	53	56	52	45	41	31	21
	16	00	0/0	»	—	—	—	2	2	2	3	4	4	4	5	6	12	13	12	12	12	10	15	39	59	59	55	50	46	34	24
	17	00	0/0	»	—	—	3	2	2	2	6	6	5	6	7	9	15	15	13	13	12	13	20	48	61	72	70	72	64	64	23
	18	00	2/0 Cc	»	—	—	—	—	—	—	—	—	4	5	7	9	15	16	17	16	—	16	22	50	87	98	95	85	50	—	—
4 VII	11	00	1/1 Cu	6 Ячмень пожелтевший, спелый	—	5	4	5	6	6	6	7	8	10	10	13	18	21	23	24	24	24	26	37	46	46	44	45	35	33	22
	12	00	0/0	2 То же	4	5	4	5	5	5	6	7	8	10	11	17	19	23	23	24	25	25	26	36	43	44	40	39	33	26	20
	14	00	0/0	»	5	4	5	6	5	6	12	10	9	10	12	15	20	25	25	25	27	27	28	37	46	49	49	48	41	39	21
	15	00	1/1 Cu	»	3	4	5	5	6	7	7	7	9	10	12	14	19	24	25	27	29	28	29	40	46	55	54	55	49	48	20
	16	00	2/2 Cu	»	—	4	4	4	5	5	5	6	8	9	10	13	18	21	23	24	26	26	29	39	50	55	53	49	47	46	25
	17	00	1/1 Cu	»	—	—	—	5	5	6	7	7	9	10	11	13	18	23	24	25	28	29	31	43	54	56	56	56	57	54	26
	18	00	0/0	»	—	5	5	5	6	6	7	7	8	10	11	13	19	24	25	27	31	32	36	50	67	72	73	76	77	—	28
6 VII	10	00	0/0	7 Ячмень тот же	3	4	4	4	5	6	7	7	8	10	11	14	18	23	24	25	26	28	29	38	46	48	47	43	38	—	—
	11	00	2/2 Cu	2 То же	4	—	4	5	4	5	5	6	7	9	10	12	15	21	22	23	25	26	28	36	43	44	37	31	23	—	—
	18	00	0/0	»	—	5	5	6	6	6	7	7	8	9	11	14	26	23	25	27	31	35	39	49	60	63	62	65	67	66	—
13 VII	8	50	2/0 Cc	8 Стерня травы суданки, почва сырая	2	2	2	3	4	4	5	5	5	5	6	6	9	11	12	10	10	11	11	16	22	27	28	30	29	33	19
	10	00	2/2Cu	2 То же	3	3	3	3	4	4	4	5	5	6	6	7	12	13	13	13	13	12	13	21	32	33	33	32	32	28	17
	11	00	2/2Cu	»	3	3	3	3	4	4	4	4	5	5	6	8	12	15	15	15	15	13	14	23	34	36	33	30	27	22	17
	12	00	2/2Cu	»	6	5	4	5	5	5	5	5	6	7	8	9	14	18	17	17	17	16	16	27	39	43	42	—	38	—	17
	13	00	3/3Cu	»	3	3	3	3	4	4	5	5	6	7	8	9	14	17	17	17	17	15	16	26	37	39	37	34	34	33	18
	16	00	3/2 Cu, Ci	»	3	3	3	3	4	4	5	5	6	6	7	9	14	17	16	16	17	16	16	27	38	41	38	35	32	28	20
27 VII	8	50	0/0	9 Стерня ячменя, почва сырая	4	4	4	4	5	6	6	6	8	10	12	14	18	22	23	24	25	26	28	30	33	33	32	28	27	26	19
	10	00	1/1 Cu	2 То же	3	3	3	4	4	5	6	6	8	10	12	15	19	23	24	27	28	30	30	33	36	37	36	34	30	27	19
	11	00	8/8 Cu, ⊙ Ci	»	—	—	—	—	—	—	4	4	4	4	5	7	8	9	11	15	16	17	19	20	22	25	31	41	34	—	17
28 VII	12	30	0/0	10 Стерня ячменя, почва сухая	5	5	5	6	7	7	8	9	11	13	15	17	20	23	24	25	27	28	29	31	34	36	35	33	30	27	21
	13	00	0/0	2 То же	6	6	6	7	7	8	9	10	12	14	16	19	23	26	27	28	29	30	31	33	36	40	43	42	40	37	21
	14	00	0/0	»	5	3	4	5	6	6	7	8	10	12	13	12	18	20	21	22	24	24	27	31	35	37	36	35	33	30	21
	15	00	0/0	»	5	5	5	5	5	5	6	7	8	10	12	14	19	23	25	26	29	30	32	33	36	36	33	30	30	26	22
	16	00	0/0	»	4	3	4	3	4	4	5	6	8	9	10	13	16	20	21	23	25	26	27	28	33	34	32	30	29	27	22
	17	00	0/0	»	—	—	4	4	4	4	5	5	7	8	10	12	16	20	20	22	25	29	32	37	44	49	50	51	44	38	24
29 VII	9	20	0/0	10 Стерня ячменя, почва сухая	5	7	5	6	6	7	8	8	9	11	12	15	19	23	24	25	27	28	30	35	41	43	43	43	40	34	22
	11	00	0/0	2 То же	5	5	6	6	6	7	8	8	10	12	14	16	20	24	26	28	30	32	33	36	40	42	35	33	32	30	22
	12	00	0/0	»	2	4	5	6	6	7	8	9	10	12	14	17	21	25	27	28	30	31	32	26	40	41	39	36	33	32	22
	14	00	0/0	»	5	5	5	5	5	6	7	8	9	11	13	15	19	23	25	26	26	30	32	33	39	38	36	33	31	31	22
	15	00	0/0	»	4	4	5	5	5	5	6	7	8	10	12	14	17	21	23	24	27	28	30	34	37	38	34	32	29	31	22
	16	00	0/0	»	—	3	4	4	5	5	6	6	8	9	11	13	16	20	21	23	25	28	29	33	36	32	34	32	30	28	22
	17	00	0/0	»	5	5	6	5	6	5	7	7	9	10	12	14	17	21	22	24	26	29	30	31	29	41	39	38	35	35	23

Column 4 - SURFACE

(English text of Russian entries)

1. Beach pebble.
2. Ditto.
3. Thin, succulent Sudan-grass (50 cm high from ground), dry soil.
4. Thin, succulent Sudan-grass (15-20 cm high), dry soil.
5. Barley in ear-forming stage, 1 meter high.
6. Barley turned yellow, ripe.
7. The same barley.
8. Sudan-grass stubble, damp soil.
9. Barley stubble, damp soil.
10. Barley stubble, dry soil.

Appendix 4.

Measurements of the spectral albedo of certain surfaces.
Tsurikovka (Kokchetav oblast), 1955

Date	Mean Solar Time hours	Cloudiness	Surface	Wavelength (millimicrons) 400	403	410	412	417	420	428	435	445	460	480	501	526	527	572	590	615	640	652	667	687	712	742	775	800	890	Integral albedo
18 VI	9	—	Wheat field	9	9	9	9	9	9	9	10	10	10	11	12	14	16	16	15	15	15	15	16	22	28	35	40	43	41	—
	10	—	Ditto	4	5	5	5	5	5	6	6	7	7	7	9	10	12	13	12	12	13	13	14	18	25	31	34	34	33	—
	11	—	"	11	11	10	10	9	9	9	9	9	9	9	9	11	13	12	14	14	14	14	15	19	26	32	34	34	31	—
	12	—	"	9	8	7	7	7	7	7	7	8	8	8	8	10	12	13	13	13	14	14	14	17	22	28	31	31	32	—
	13	—	"	14	17	19	18	17	17	17	16	15	14	13	13	14	16	16	15	16	15	16	17	21	27	33	35	36	—	—
	14	—	"	12	12	10	10	9	9	9	9	9	8	8	9	10	11	12	12	12	12	13	14	16	22	27	30	31	30	—
20 VI	10	—	"	6	6	7	7	6	7	7	7	8	7	8	8	10	12	11	11	11	11	11	12	16	24	27	30	32	27	—
	12	—	"	8	8	8	8	8	8	8	9	9	9	9	10	12	12	14	14	14	14	15	15	19	28	35	36	34	29	—
	15	—	"	—	—	8	8	8	8	8	8	8	8	8	9	11	12	12	12	13	13	14	15	20	28	35	37	36	31	—
24 VI	11	—	Bare fallow	8	8	8	8	8	9	9	9	9	10	10	11	12	13	14	14	14	15	16	17	18	19	20	21	21	21	—
	13	—	Ditto	7	7	7	7	7	8	8	8	8	8	8	9	10	11	13	13	14	15	15	15	16	16	16	19	20	19	—
	15	—	"	5	5	5	5	6	6	7	7	8	8	8	8	9	10	10	12	13	14	14	14	14	15	15	17	17	15	—
	17	—	"	5	5	4	4	5	5	5	5	6	6	7	7	9	9	10	11	13	14	14	14	14	15	15	16	16	14	—
30 VI	10	—	"	5	5	5	5	5	6	6	6	6	7	7	7	8	10	10	11	12	13	14	14	14	14	14	15	14	14	—
	11	—	"	5	5	5	5	5	6	6	6	6	6	7	7	8	10	10	11	12	13	14	15	15	16	17	17	17	15	—
	12	—	"	4	4	4	4	4	4	4	4	4	4	5	5	6	8	9	9	11	12	12	12	12	13	14	12	12	12	—